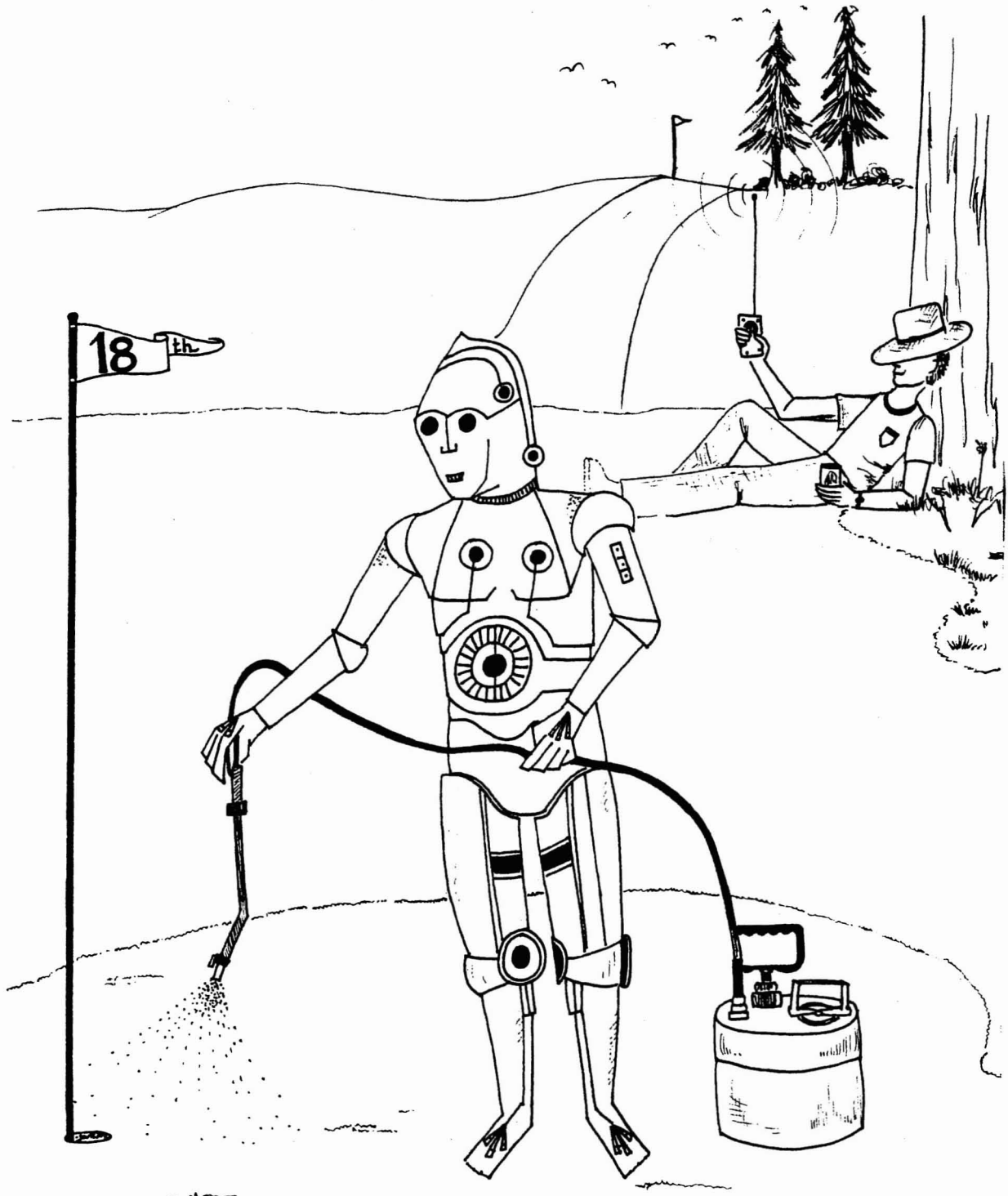


SPRAY SYSTEMS FOR TURFGRASSES: CALIBRATING SPRAYERS AND MIXING PESTICIDES

C. L. Murdoch



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SPRAY SYSTEMS FOR TURFGRASSES: CALIBRATING SPRAYERS AND MIXING PESTICIDES

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COMPONENTS OF THE SPRAY SYSTEM

The purpose of the sprayer is to accurately meter and distribute pesticides. Pesticides are packaged in concentrated form to facilitate handling. In order to uniformly distribute the active ingredient of the pesticide over the area sprayed, it must be diluted with a suitable carrier (in this case, water). The diluted pesticide must then be uniformly distributed in a manner that gives optimum coverage with minimal drift potential.

The basic parts of a sprayer are presented in Figure 1.

The Tank

The most common materials for construction of tanks are fiberglass, mild steel, and stainless steel. Mild steel is susceptible to corrosion damage and must be cleaned thoroughly after each use. Factory-applied interior paint is usually available for mild steel tanks. Fiberglass and stainless steel tanks are not affected by most common agricultural pesticides.

Cylindrical or rounded-bottom tanks are preferred to rectangular ones because they eliminate dead spots during mixing and agitation. Tanks should also have a large opening for access in cleaning and rinsing.

Mixing and agitation of spray solutions is essential to insure uniform distribution of the active ingredient. Only mild agitation is required for pesticides formulated as solutions or emulsifiable concentrates. Pesticides formulated as wettable powders require more vigorous and continuous agitation. Mechanical agitators should be a part of sprayers used for wettable powder pesticides. The agitation system should be kept operating at all times when wettable powders are in the spray tank to prevent them from settling out.

The Pump

The basic types of pumps used for sprayers are rotary, centrifugal, piston, and diaphragm. Rotary and centrifugal pumps are perhaps the most commonly used on agricultural sprayers. Consult your

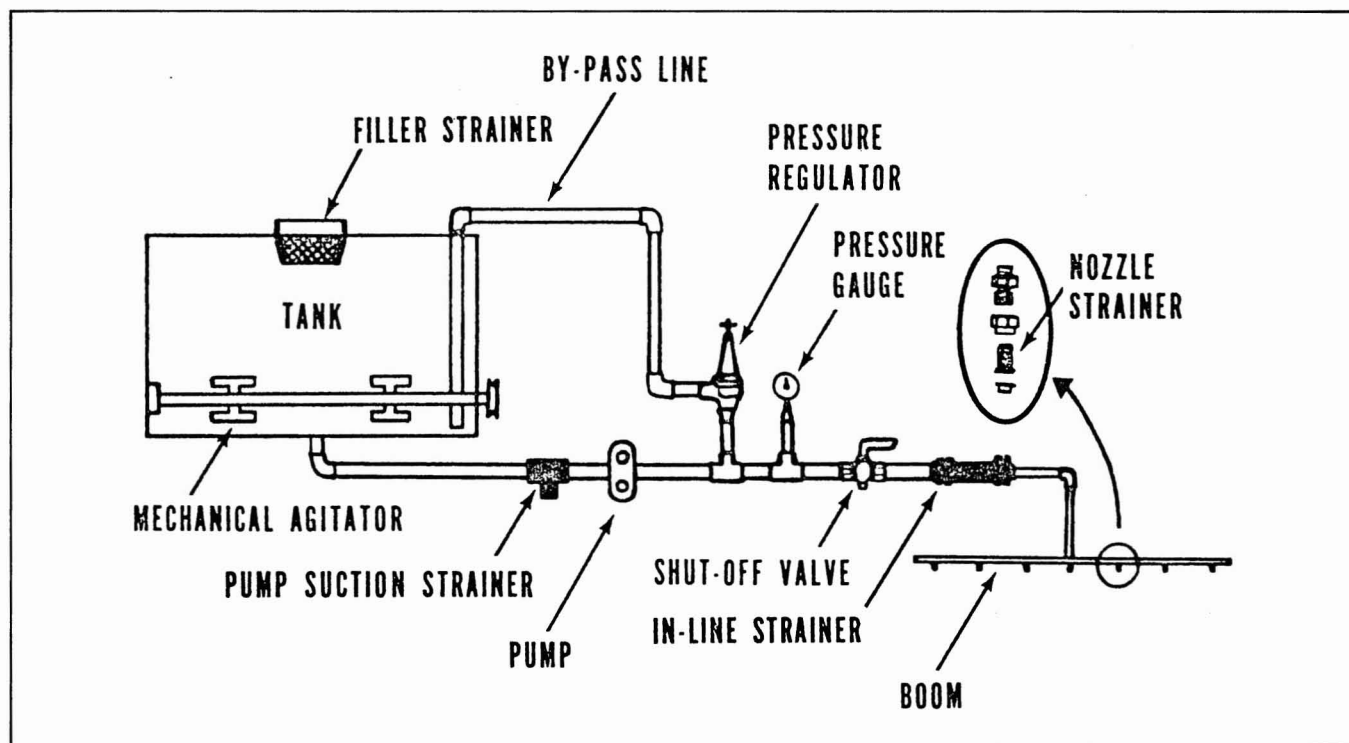


Figure 1. Components of a typical spray system. (From Robert G. Curley and Wesley E. Yates. 1974. Proceedings of the California Golf Course Superintendents Institute. Pp. 37-41.)

equipment supplier for pump specifications. Make sure the pump will supply sufficient capacity (gallons per minute) and proper pressure for the job required. Other considerations are longevity, ability to handle corrosive materials, cost, and serviceability.

Strainers and Screens

Screening is necessary to keep foreign materials out of the spray nozzles and to reduce wear on the pump. All materials poured into the tank should be screened with a coarse (10- to 20-mesh) screen at the opening of the tank. A 25- to 50-mesh screen should be placed between the tank and the suction side of the pump to prevent foreign material from entering the pump. A 50- to 100-mesh screen should be placed in the line between the pump and the spray boom and, additionally, 50- to 100-mesh screens should be placed in each nozzle. Fifty-mesh screens are the smallest size recommended when spraying wettable powders.

The Pressure Regulator

A pressure regulator is required to adjust the pressure for spraying. Most agricultural pesticides should be sprayed at the lowest pressure compatible with the particular spray nozzles in use; this will prevent excessive atomization of the spray droplets. Pressures of 25 to 40 pounds per square inch (psi) are adequate for most materials and most spray nozzles.

The Pressure Gauge

A pressure gauge is essential to measure the pressure at which the spray solution is being applied. Calibration methods covered later in this publication depend on the operator's knowing the spray pressure. The pressure gauge should be located as near as possible to the spray boom to prevent erroneous readings due to friction loss. Keep in mind that pressure may drop in nozzles near the end of the boom when several nozzles are operating at once. When calibrating sprayers, it is desirable to catch the liquid from several nozzles (or even each nozzle) on the boom for a given length of time to determine if nozzle output is uniform.

The By-pass Line

The by-pass line diverts liquid from the pressure regulator valve to the tank in order to reduce the pressure on the line. It also helps agitate spray solutions. The by-pass line should not be considered

sufficient for agitation of wettable powders, however. If the spray tank does not have mechanical agitation, it should have a separate line with holes in it from the pressure side of the pump (before the pressure regulator valve), extending into the tank to provide movement of the liquid.

Spray Nozzles

Spray nozzles are perhaps the most important part of the spray rig. They perform the vital functions of breaking up the spray stream into properly sized droplets, metering the spray, and distributing it evenly over the area.

There are three common types of spray nozzles used on agricultural sprayers: the flat fan, the hollow cone, and the solid cone. For broadcast pesticide application, the flat-fan type is most commonly used.

Nozzles may be constructed of brass, stainless steel, ceramics, or nylon. Advantages and disadvantages of each type are related to corrosion resistance, wear resistance, and cost. Consult your spray equipment supplier for specifications of the various nozzle types.

Abrasive materials, such as wettable powders, may cause rapid wear of spray nozzles made of soft metals or nylon. This may change the nozzle delivery rate or the spray pattern drastically. These should be checked periodically. If the sprayer is used often, a systematic schedule of nozzle tip replacement is good insurance for correct spray rate and pattern. Remember that in relation to the cost of pesticides, the cost of replacing worn nozzle tips is insignificant. Nozzle screens are also a vital part of a spray system. They perform the important task of screening out foreign materials that might clog the nozzles and large abrasive materials that might cause excessive wear. As mentioned previously, nozzle screens should be 50 to 100 mesh, with 50 mesh being the smallest size for wettable powders.

Nozzle screens have to be cleaned often to prevent loss of spray pressure. Since pressure gauges are located ahead of the spray nozzles, the gauge will not warn the operator of pressure loss due to a clogged spray screen. Wash the screen thoroughly in soapy water. Do not use a wire brush to clean the screen; a soft toothbrush may be used. Nozzle screens should be replaced if they are damaged or clogged so badly they cannot be cleaned.

No-drip nozzle screens are available and will prevent dripping of pesticides when the shut-off valve is closed. These screens have a spring-loaded

mechanism to stop the flow of liquid when pressure to the nozzle is stopped. They cause a slight reduction in nozzle delivery rate at a given pressure. Consult the manufacturer's specifications for the delivery rate of nozzles with no-drip screens.

Nozzle tips may become clogged occasionally, even though screens are being used. Wire, knife blades, and other hard objects should not be used to unstop nozzle tips because they will enlarge or change the shape of the opening and alter the spray rate or spray pattern. A soft-bristled toothbrush or a small copper wire will remove objects without damage to the tips.

The relationship between nozzle size, spray pressure, and spray delivery rate is discussed later.

SPRAYER CALIBRATION AND PESTICIDE CALCULATIONS

Accurate sprayer calibration and calculation of amounts of pesticides to add to the spray tank are essential for proper use of pesticides. Too little pesticide will fail to control the pest. Too much pesticide is wasteful and may result in excessive damage to desirable plants or adverse effects on the environment. Sprayer calibration and pesticide calculations are simple. A few basic pieces of information are needed. The following discussion of the principles of sprayer calibration and the formulas, tables, and figures provided should enable one to quickly and accurately calibrate a sprayer and calculate amounts of pesticides to apply. Practice with these methods will help develop confidence in their use.

Calibration of Sprayers

Only three pieces of information are needed to accurately calibrate a sprayer. These are (1) the discharge rate of each spray nozzle, (2) the spacing of the nozzles on the boom, and (3) the ground speed of the sprayer. This information is easily obtained. Two parts of the information are fixed: the discharge rate of the nozzles and the spacing of the spray nozzles on the boom. The third part, the ground speed, is easily determined.

Nozzle discharge rate. Flat-fan spray nozzles are the type most commonly used in herbicide application. They are identified by a four-digit number that supplies important information. The first two digits (or three, if the angle is in excess of 100°) designate the angle of spray discharge from the nozzle at a designated spraying pressure of 40 psi. This, as we will see later, is important in determining the spacing of the nozzles on the boom. The second two digits designate the nozzle output in gallons (or parts of a gallon) per minute, also at the designated spray pressure of 40 psi. Thus an 8002 nozzle produces a spray pattern of 80° and delivers 0.2 gallons per minute.

Tables 1 and 2 illustrate the effect that spray pressure has on spray angle and nozzle discharge rate. Forty psi should be the maximum spraying pressure. If a pressure lower than 40 psi is used, note the effect this has on spray angle and nozzle output, and adjust the nozzle spacing and travel speed accordingly. Excessively high spraying pressures will result in a large proportion of small spray particles, increasing the drift hazard.

Table 1. Spray angle of flat-fan spray tips at 20 and 40 psi

Nozzle tip number	Spray pressure	
	20 psi	40 psi
8005	71°	80°
8008	72°	80°
9506	86°	95°
6506	54°	65°

Table 2. Spray delivery rate of flat-fan spray tips at 20, 30, and 40 psi

Nozzle tip number	Spray pressure		
	20 psi	30 psi	40 psi
Nozzle delivery rate (gal/min)			
8005	0.35	0.43	0.50
8008	0.56	0.69	0.80
9506	0.42	0.52	0.60
6506	0.42	0.52	0.60

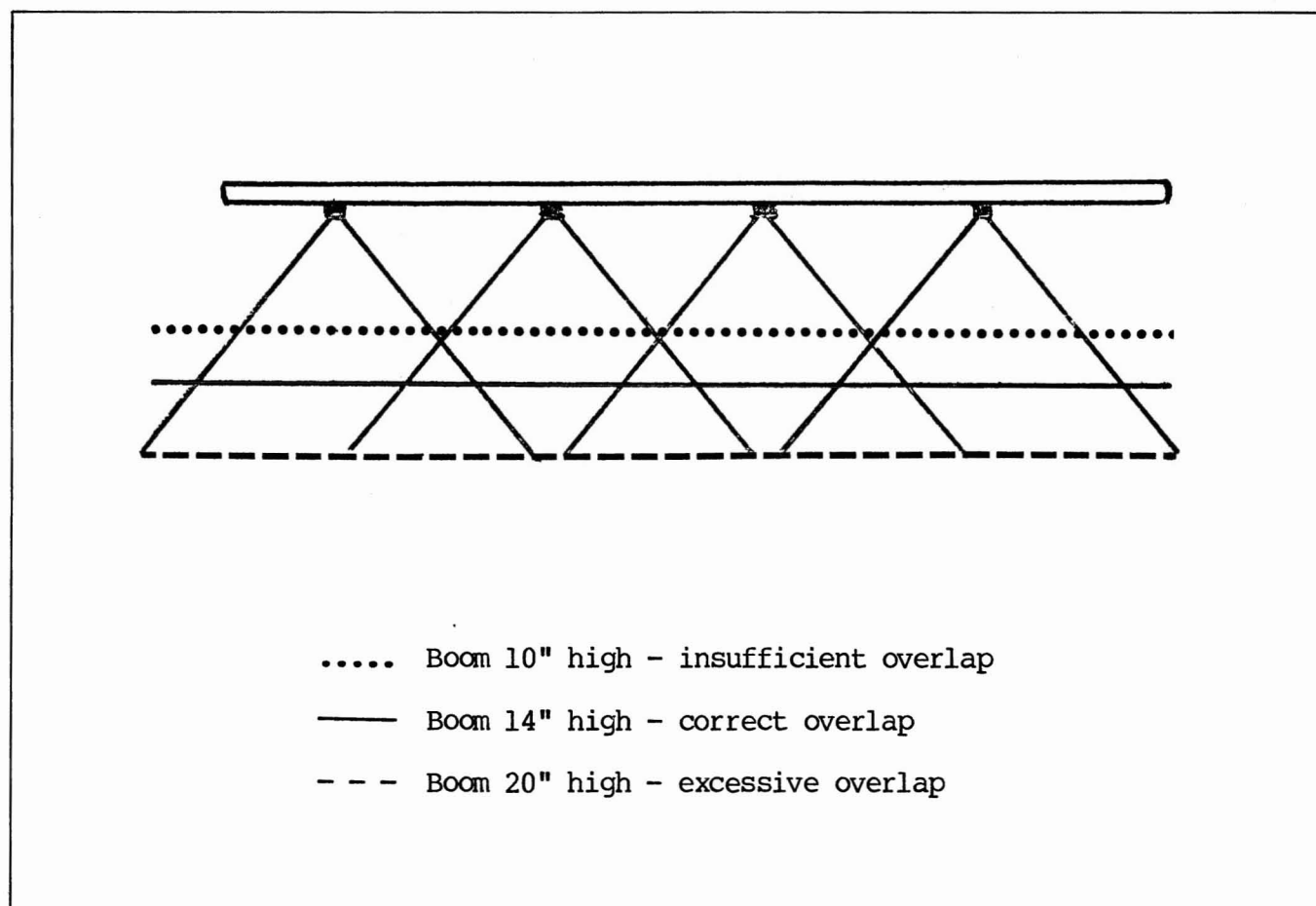


Figure 2. Effect of boom height on spray pattern. Nozzles are 80° angle flat-fan type spaced 18 inches apart on the boom.

Nozzle spacing. Another important factor to consider in setting up a spray boom is the relationship between nozzle spray angle, nozzle spacing on the spray boom, and the proper operating height of the boom. A simple illustration will help to clarify this relationship (Figure 2).

As Figure 2 shows, it is critical that the proper spacing and height for nozzles be used. Perfect calibration of nozzle output will not give proper pesticide distribution if the nozzles are not spaced properly or the boom is not adjusted to the proper height. Excessive boom height will also increase the potential for drift hazard.

Table 3 gives the proper boom height for different nozzles at different spacings on the boom.

Ground speed of sprayer. The ground speed of the sprayer is the third bit of information needed to calibrate a sprayer. If the tractor is not equipped with a speedometer, the speed can easily be determined by measuring the time required to travel a measured distance. Since 88 feet = 1/60 of a mile, this is a convenient distance to use for the sake of simplifying calculations.

First measure 88 linear feet and mark it with stakes or other convenient markers. Then determine a satisfactory gear and throttle setting for spraying. Mark the throttle setting for future reference, or if the tractor is equipped with a tachometer, note the revolutions per minute (rpm). Next determine the time, in seconds, required to travel the 88 feet. Since 60 miles per hour = 88 feet in one second, 60 divided by the measured time in seconds required to travel 88 feet = speed in miles per hour (mph). Table 4 covers the range of speeds normally used in spraying and will eliminate the need for calculations.

Determining Sprayer Output

Once the needed information is obtained, the sprayer output in gallons per acre may be calculated by the following formulas:

1. Acres covered in one hour by one nozzle = $(GS \times 5280 \times NS)/43,560$

Where:

GS = ground speed in mph

5280 = feet in one mile

NS = nozzle spacing in feet

43,560 = square feet in one acre

2. Sprayer output in gal/acre = $(GPM \times 60)/A$

Where:

GPM = nozzle output in gal/min

60 = minutes in one hour

A = acres covered in one hour by one nozzle

For example, if you are spraying at 3 mph with 8004 nozzles spaced 18 inches (1.5 feet) apart, at 40 psi, the spray rate is:

1. $(3 \text{ mph} \times 5280 \times 1.5 \text{ ft})/43,560 = 0.55 \text{ acre/hr/nozzle}$
2. $(0.4 \text{ GPM} \times 60)/0.55 \text{ acre/hr/nozzle} = 43.6 \text{ gal/acre}$

Table 5 gives sprayer output when the nozzle output and ground speed are known.

Preparation of Spray Mixtures

Once the spray rate in gallons per acre is determined, it is a simple matter to determine the amount of pesticide to place in the spray tank. Since pesticide label recommendations are usually made in terms of formulated materials per acre, all calculations are made on this basis.

Mixing dry pesticide formulations. Many pesticides are formulated in a dry form (wetable powder, soluble powder, and so on) that is mixed with water and sprayed. To calculate the amount of dry formulation to place in the spray tank, use the following formula:

$$Wt = R(V/GPA)$$

Where:

Wt = weight of material for spray tank

R = desired rate of pesticide per acre

V = volume of spray solution in gallons

GPA = spray rate in gal/acre

(Wt and R must be in same units)

For example, you wish to mix 100 gallons of spray mixture with a 50 percent wettable powder and spray at the rate of 2 pounds formulated material per acre. If the spray rate is 40 gallons per acre, then $2(100/40) = 5$ pounds of wettable powder per 100 gallons of spray solution.

Table 6 explains how much powder to use per gallon of solution when spraying at different rates. For example, if you wish to mix 75 gallons of spray solution to apply at the rate of 2 pounds formulated material per acre, and the spray rate is 40 gallons per

Table 3. Relationship between nozzle spacing, nozzle spray angle, and nozzle height

Nozzle spacing (inches)	Nozzle spray angle	
	65°	80°
Nozzle height (inches)		
12	13	10
16	17	13
18	19	14
20	21	16
24	25	19

Source: C. R. Kaupke and R. G. Curley. 1964. Sprayer calibrations and calculations. Univ. of California, Davis.

Table 4. Speed required to travel 88 linear feet in different lengths of time

Time elapsed (seconds)	Speed (mph)
30	2.0
24	2.5
20	3.0
17	3.5
15	4.0
12	5.0

Table 5. Relationship between ground speed, nozzle discharge rate, and spray rate in gallons per acre for nozzles spaced 18 inches (1.5 feet) apart ^a

Nozzle discharge rate (gal/min)	Ground speed (mph)						
	2.0	2.5	3.0	3.5	4.0	4.5	5.0
	Spray rate (gal/acre)						
0.2	33.0	26.4	22.0	18.9	16.5	14.7	13.2
0.3	49.5	39.6	33.0	28.3	24.8	22.0	19.8
0.4	66.0	52.8	44.0	37.7	33.0	29.3	26.4
0.5	82.5	66.0	55.0	47.1	41.3	36.7	33.0
0.6	99.0	79.2	66.0	56.6	49.5	44.0	39.6
0.7	115.5	92.4	77.0	66.0	57.8	51.3	46.2
0.8	132.0	105.6	88.0	75.4	66.0	58.7	52.8
0.9	148.5	118.8	99.0	84.9	74.3	66.0	59.4
1.0	165.0	132.0	110.0	94.3	82.5	73.3	66.0
1.1	181.5	145.2	121.0	103.7	90.8	80.7	72.6
1.2	198.0	158.4	132.0	113.1	99.0	88.0	79.2
1.3	214.5	171.6	143.0	122.6	107.3	95.3	85.8
1.4	231.0	184.8	154.0	132.0	115.5	102.7	92.4
1.5	247.5	198.0	165.0	141.4	123.8	110.0	99.0
1.6	264.0	211.1	176.0	150.9	132.0	117.3	105.6

^a For other nozzle spacings, spray rate $\times \frac{18}{\text{nozzle spacing}}$ = correct spray rate.

Table 6. Amount of dry formulation pesticide to use per gallon of spray solution when spraying at different rates

Desired rate (lb formulation/acre)	Spray rate (gal/acre)			
	40	50	60	70
	oz formulation/gal spray solution			
1	0.4	0.3	0.3	0.2
2	0.8	0.6	0.5	0.5
3	1.2	1.0	0.8	0.7
4	1.6	1.3	1.1	0.9
5	2.0	1.6	1.3	1.1
6	2.4	1.9	1.6	1.4
7	2.8	2.2	1.9	1.6
8	3.2	2.6	2.1	1.8
9	3.6	2.9	2.4	2.1
10	4.0	3.2	2.7	2.3

acre, then 75 gallons of spray solution \times 0.8 ounce per gallon = 60 ounces (or 3 pounds, 12 ounces).

Mixing liquid formulations. Pesticides may be formulated in liquid form (soluble concentrates, emulsifiable concentrates, and flowables). To calculate the amount of liquid formulation to add to the spray tank, use the following formula:

$$\text{Fl oz} = R(V/\text{GPA})$$

Where:

Fl oz = fluid ounces of material for spray tank

R = desired rate in fluid ounces of pesticide per acre

V = volume of spray in gallons

GPA = spray rate in gal/acre

For example, if you wish to mix 75 gallons of a spray mixture to be sprayed at 32 ounces per acre, the pesticide is a liquid formulation, and the spray rate is 50 gallons per acre, then $32(75 \text{ gallons}/50 \text{ gallons per acre}) = 48 \text{ ounces}$ (or 3 pints) of formulation per 75 gallons of mixture.

Table 7 explains how much liquid to use per gallon of solution when spraying at different rates. For example, if you wish to mix 150 gallons of spray solution to apply at the rate of 3 pints formulated material per acre, and the spray rate is 60 gallons per acre, then $150 \text{ gallons of spray solution} \times 1.1 \text{ ounces per gallon of spray solution} = 165 \text{ ounces}$ (or 1 gallon, 1 quart, and 5 fluid ounces).

Table 7. Amount of liquid formulation pesticide to use per gallon of spray solution when spraying at different rates

Desired rate (fl oz formulation/ acre)	Spray rate (gal/acre)			
	40	50	60	70
	fl oz formulation/gal spray solution			
16 (1 pt)	0.4	0.3	0.5	0.2
32 (1 qt)	0.8	0.6	0.8	0.5
48 (3 pt)	1.2	1.0	1.1	0.7
64 ($\frac{1}{2}$ gal)	1.6	1.3	1.3	0.9
80 (5 pt)	2.0	1.6	1.6	1.1
96 (6 pt)	2.4	1.9	1.9	1.4
112 (7 pt)	2.8	2.2	2.1	1.6
128 (1 gal)	3.2	2.6	2.4	1.8

Conversion Factors for Mixing Pesticides

Liquid measure:

- 3 teaspoons = 1 tablespoon
- 2 tablespoons = 1 fluid ounce
- 16 tablespoons = 8 fluid ounces = 1 cup
- 1 pint = 16 fluid ounces
- 2 cups = 1 pint
- 4 quarts = 1 gallon
- 1 gallon = 128 fluid ounces
- 1 gallon = 8 pints

Dry measure:

- 1 pound = 16 ounces

Linear distance:

- 1 mile = 5280 feet

Area:

- 1 acre = 43,560 square feet

Speed:

- 1 mph = 88 feet/minute
- 60 mph = 88 feet/second

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